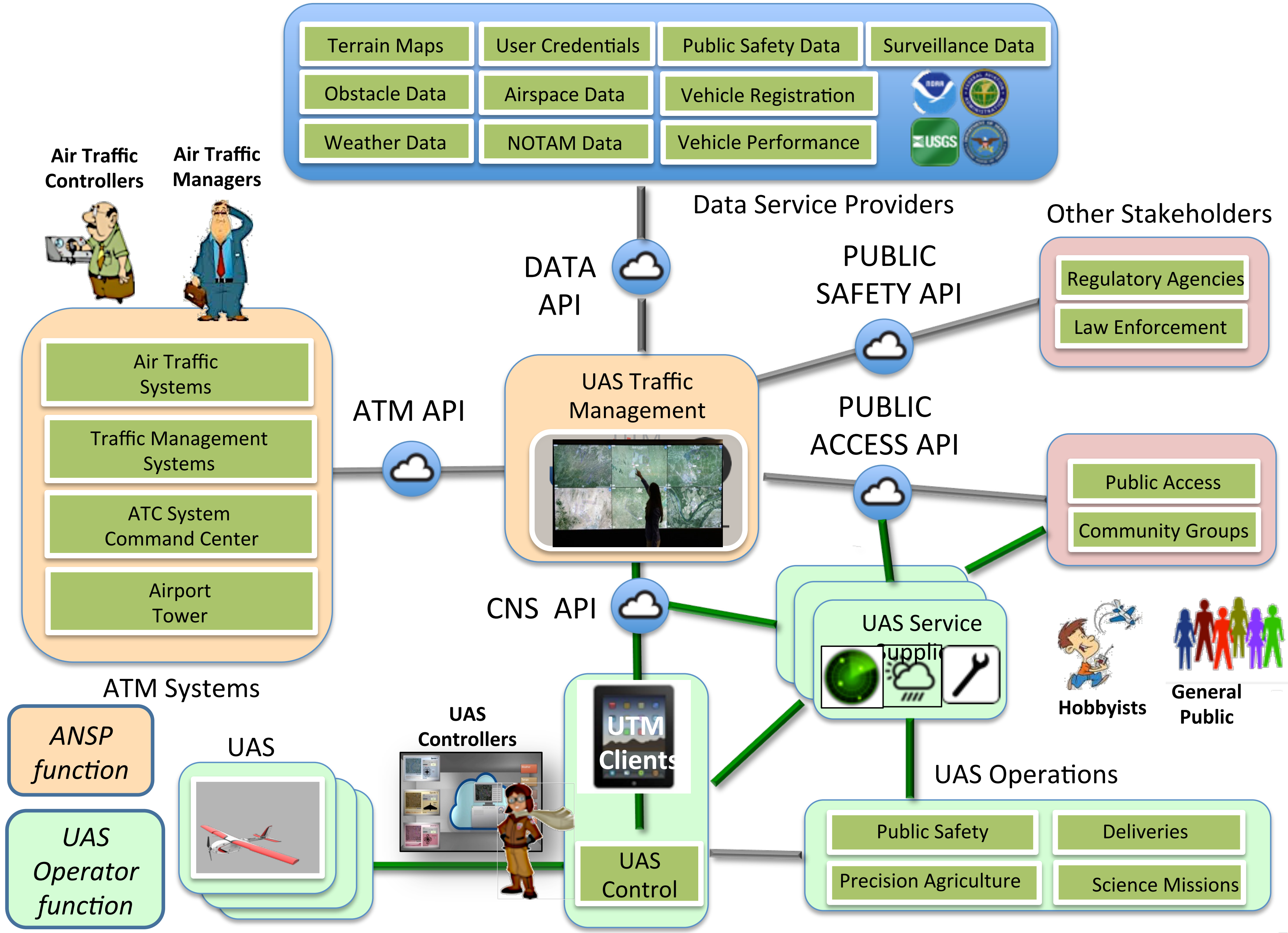
Creating Weather-Related Services for UTM

By Daniel Mulfinger

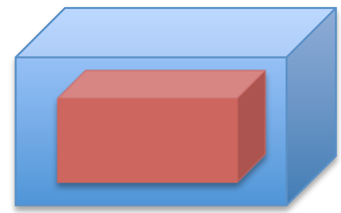
Outline

- Introduction
- Service Architecture
- Example 1 – Conformance Buffer
- Example 2 – Operational Wind Constraint
- Data Products



Terrain Maps
User Credentials
Public Safety Data
Surveillance Data
Obstacle Data
Airspace Data
Vehicle Registration
Weather Data
NOTAM Data
Vehicle Performance
Data Service Providers
Air Traffic Controllers
Air Traffic Managers
DATA API
PUBLIC SAFETY API
Other Stakeholders
Regulatory Agencies
Law Enforcement
Air Traffic Systems
Traffic Management Systems
ATC System Command Center
Airport Tower
ATM API
UAS Traffic Management
PUBLIC ACCESS API
Public Access
Community Groups
CNS API
UAS Service Supplier
Hobbyists
General Public
ATM Systems
ANSP function
UAS Operator function
UAS
UAS Controllers
UTM Clients
UAS Control
UAS Operations
Public Safety
Deliveries
Precision Agriculture
Science Missions

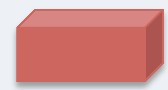
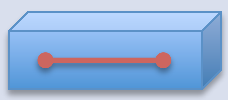
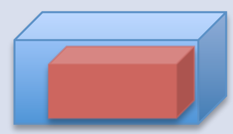
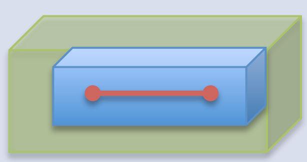
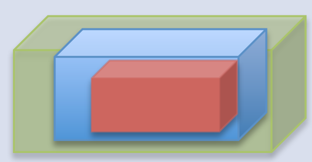
Example 1:
Operation Buffer Sizing



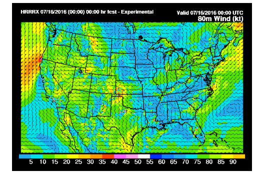
Goal: Calculate UAS conformance buffer sizes based on wind and performance

Approach: Create UAS support service to calculate conformance buffer sizing

Airspace Buffering

UTM Creates	Geography Types		Notes
	Flight Plan	Volume	
Flight Geography			Submitted by operator
Conformance Geography			Used for determining non-conformance of position updates
Buffers Required	u,v,w,t	u,v,w,t	Calculated using wind data
Protected Geography			Used for separation when approving operations
Buffers Required	u,v,w,t	u,v,w,t	Based on GPS error

Conformance Buffer Calculation



- NOAA's HRRR Weather Model:
  - Applied to the Reno-Stead Area
  - Determined maximum wind component (u or v) at 10 meters altitude
  - Determined direction of wind from components

- SJSU Sonar Anemometer Data
  - Provides 3-dimensional wind vector data
  - Used this to determine the proportion of vertical wind to the horizontal wind:
- Calculation based on
  - Large number of flight plans
  - Type of vehicle – expected recovery time
  - Winds in operation area

Example 2:
HRRR Wind Impact Server

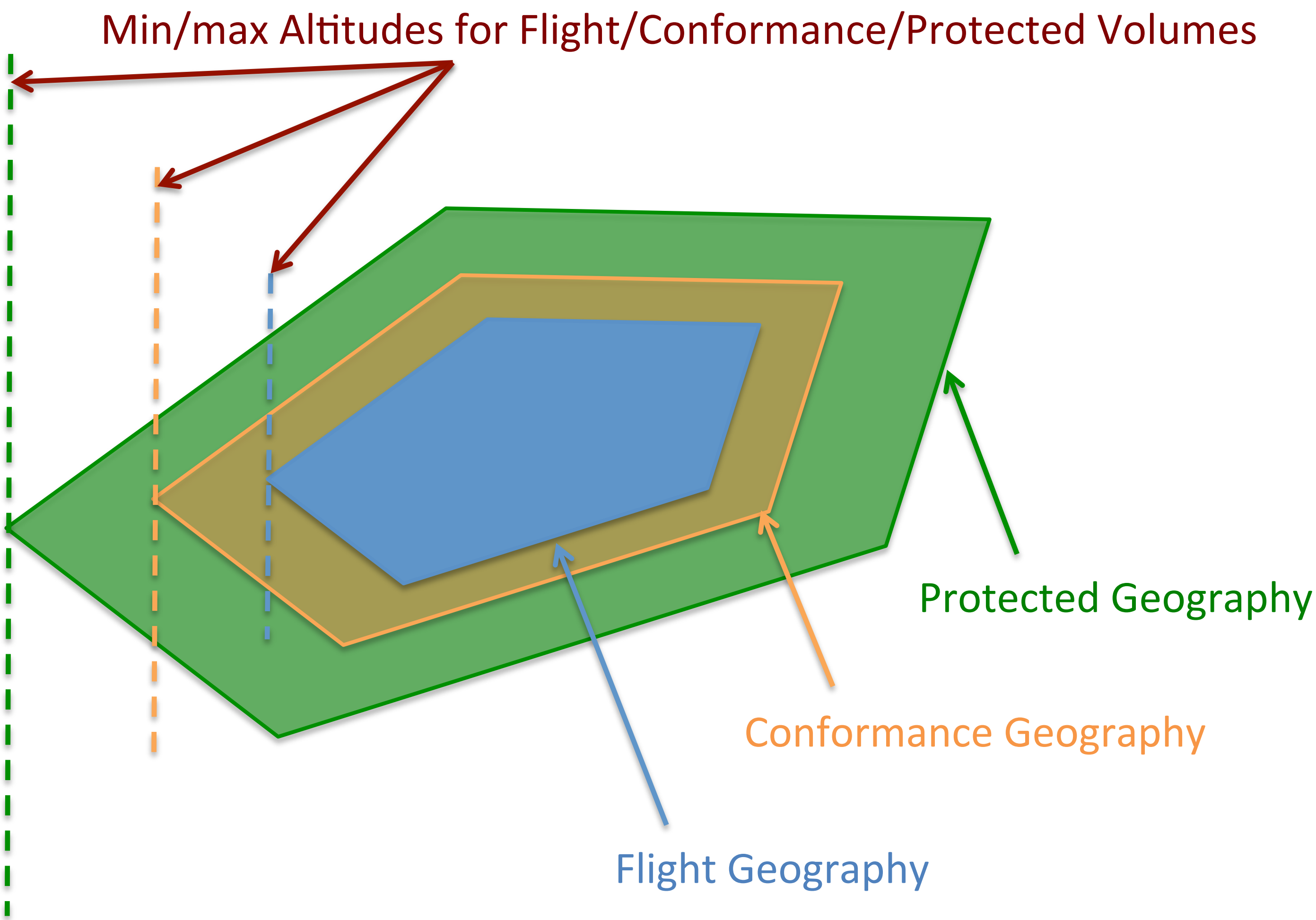
Goal: Evaluate the impact of forecasted winds on UTM operations

Approach: Create a wind data provider and wind impact server.

Input/Output

- Input:
  - Operation plan
  - Vehicle performance
  - HRRR data
- Output:
  - Weather-checking result:
    - ACCEPT, WARNING, REJECT
    - Explanation

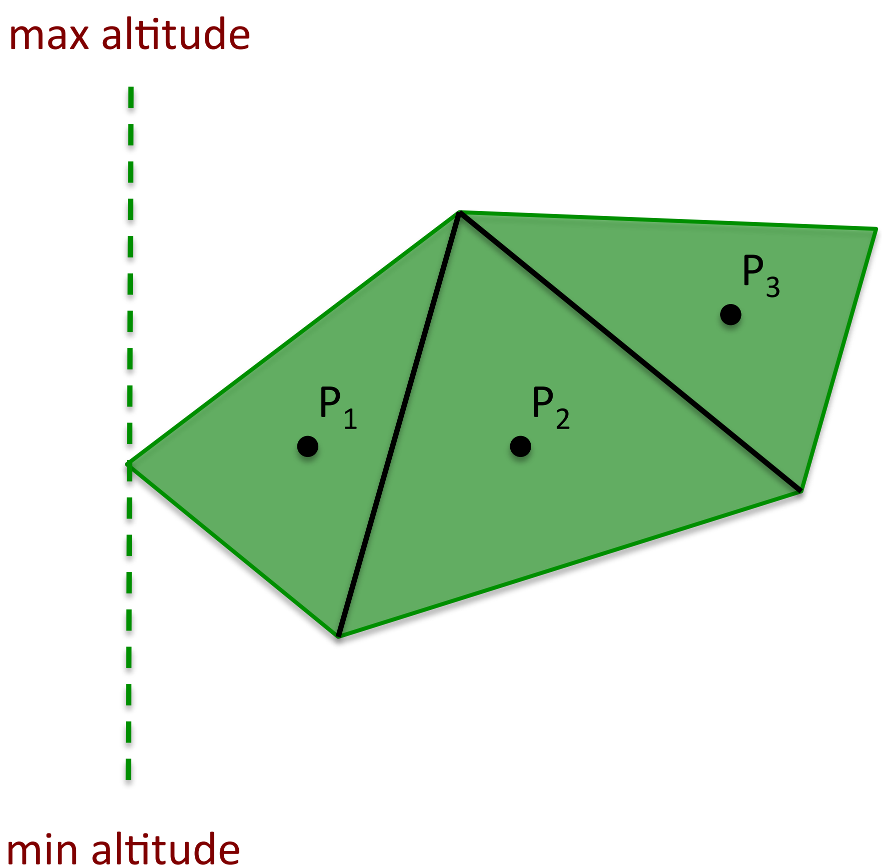
Operation Volume (i.e., Segment)



Wind Checking Algorithm

1. Sample points within the **PROTECTED VOLUME**
2. Compute wind velocity at the sample points
3. Check wind-velocity against vehicle performance data
4. Made decision for each segment & flight
   – Then make the decision for each flight

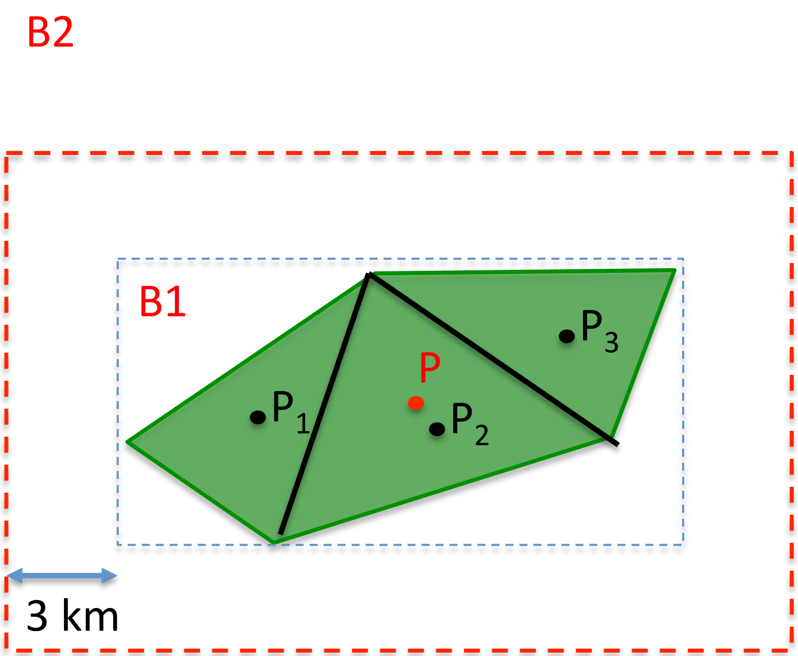
Step 1: Sample 4D Points



- Time: whole duration
  [protected-time-begin, protected-time-end]
- Altitude:
  (min-alt + max-alt) / 2
- Sample Lat/lon:
  - Triangulation.
  - Center points of all triangles (P_1,P_2,P_3)

Delaunay Triangulation: https://en.wikipedia.org/wiki/Delaunay_triangulation
Java package used: https://www.cs.bgu.ac.il/~benmoshe/DT/Delaunay%20Triangulation%20in%20Java.htm

Step 2: Find the relevant HRRR grid data

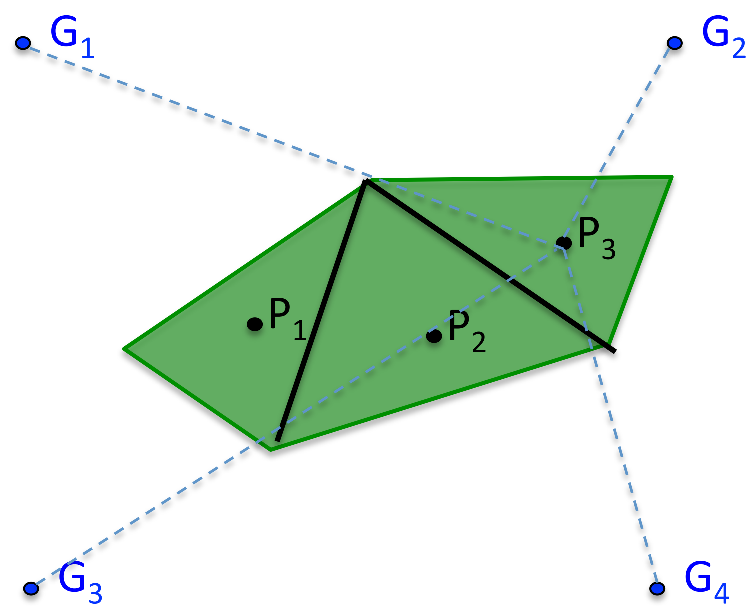


1. Find the bounding box B1 of the protected polygon
2. Find the center P of the bounding box
3. Find a square B2 with P as center and distance of 3km from each side of B1 (HRRR grid is of 3KM resolution)
4. Find all grid points within B2:
   Database query requires a box
   with max/min lat/lon bounds
5. Use wind value at 80 ft altitude (for now)

NOTE: without being able to connect to the HRRR database, current test data are generated with:

- Corners of B1 act as wind grid points
- Wind-strength at each grid point is randomly generated.

Step 3: Compute wind-strength at each sample points



Wind strength at each P_i point is **interpolated** using wind-strength values at the relevant HRRR wind grid points G_i:
Actual Implementation: **Inverse Distance Interpolation**
(https://en.wikipedia.org/wiki/Inverse_distance_weighting)

Step 4: Weather Recommendation

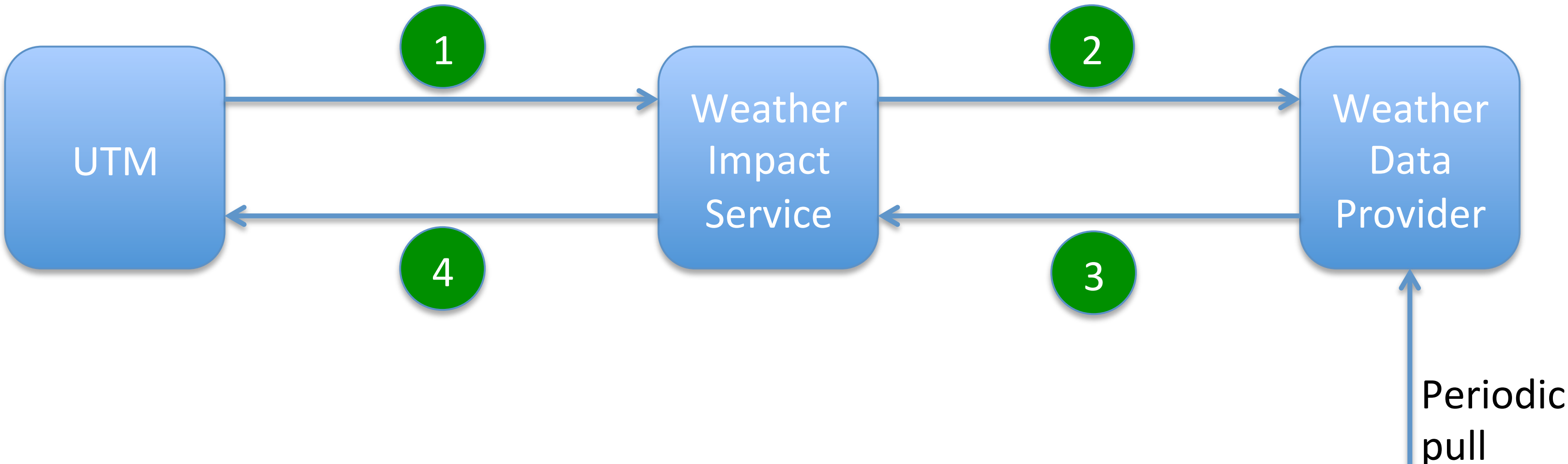
- Decision Point: wind-strength vs max-air-speed

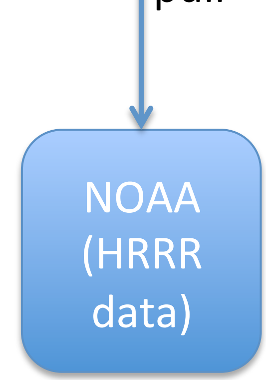
  >= 3 x : REJECT

  1x – 3x: WARNING

  0 - 1x : ACCEPT
- Segment:
  - One point REJECT → whole segment REJECT
  - Else, one point WARNING → whole segment WARNING
  - Else, ACCEPT segment
- Submitted Flight:
  - One segment REJECT → whole flight REJECT
  - Else, one segment WARNING → whole flight WARNING
  - Else, ACCEPT flight

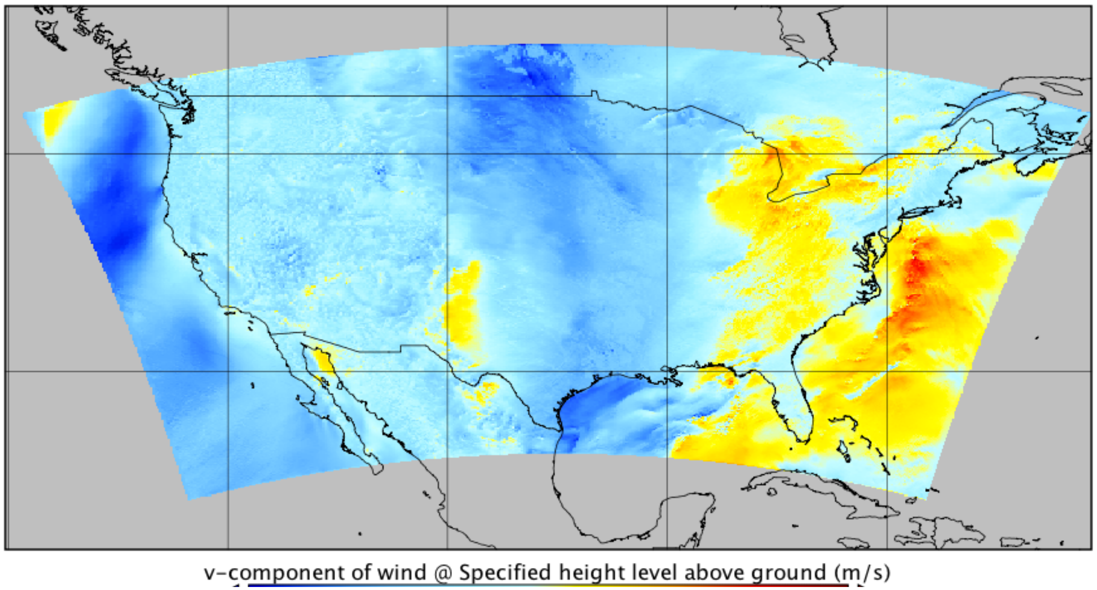
Data Flow





1. UTM posts an operation and vehicle information
2. Weather impact service pulls weather information for the specific operation region (space and time)
3. Weather service returns the smallest grid that contains the operation region
4. Weather impact service compares vehicle rating with the weather grid and returns any concerns to UTM

High Resolution Rapid Refresh - HRRR



-Produced by NOAA
-Continental US coverage
-3km resolution
-Forecasts up to 15 hours in 1-hour increments (15-min for subset)
-Updated hourly

-Resolved in pressure or sigma hybrid vertical levels
-Lambert conformal projection
-Available by anonymous FTP/HTTP

0.5 GB/files * 16 files/hr * 24 hr/day = 192 GB/day

Questions

- Is HRRR the most applicable weather product for low-level weather parameters?

- Is there a product with adaptively higher resolution in urban areas?

- Can we be part of the solution by creating an API for UAS's to report their own winds?

Conclusion

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- Data Product

Questions?

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